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Report on the Usefulness of AVHRR and CZCS Sensors for Delineating Potential Disposal Operations at the 106-Mile Site

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Report on the usefulness of AVHRR and CZCS sensors for delineating potential disposal operations at the 106-Mile Site

by

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In this work data from the AVHRR sensor for 18 TIROS-N series satellite passes were examined for signs of ocean dumping at Deepwater Dumpsite 106. The passes selected occurred within five days following the actual dump although in most cases they occurred on the same day or that following the day of the dump. All spectral channels were analyzed. In addition the difference and the ratio of channels 1 and 2 were used. No dumping is evident in any of the images. If dumping is actually visible the signal must be very weak at the 1 km resolution of the AVHRR sensor. Because of this the images would have to be absolutely clear. Small scattered clouds or thick haze add too much variability to detect a weak signal. This renders AVHRR data of marginal value (if of value at all) for such work. Because the exact location of the dumps was not known it is possible that the signal is detectable. For this to be true the dumps would have had to occur quite far from the location provided on the Coast Guard records. These records give only the site as e.g. dumpsite 106, no actual coordinates.

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EXECUTIVE OVERVIEW

In this work data from the AVHRR sensor for 18 TIROS–N series satellite passes were examined for signs of ocean dumping at Deepwater Dumpsite 106. The passes selected occurred within five days following the actual dump although in most cases they occurred on the same day or that following the day of the dump. All spectral channels were analyzed. In addition the difference and the ratio of channels 1 and 2 were used. No dumping is evident in any of the images. If dumping is actually visible the signal must be very weak at the 1 km resolution of the AVHRR sensor. Because of this the images would have to be absolutely clear. Small scattered clouds or thick haze add too much variablility to detect a weak signal. This renders AVHRR data of marginal value (if of value at all) for such work. Because the exact location of the dumps was not known it is possible that the signal is detectable. For this to be true the dumps would have had to occur quite far from the location provided on the Coast Guard records. These records give only the site as e.g. dumpsite 106, no actual coordinates.

INTRODUCTION

As part of its ongoing monitoring activities for Deep Water Dump Site 106, the Environmental Protection Agency (EPA) contracted to the University of Rhode Island (URI) to investigate whether or not it is possible to detect dumped waste in AVHRR satellite data. The primary focus was to be on the use of the visible channels (Channel 1: $0.55 - 0.9\mu m$, Channel 2: $0.725 - 1.1\mu m$ for TIROS–N; Channel 1: $0.58 - 0.6\mu m$, Channel 2: $0.725 - 1.1\mu m$ for NOAA–6 to NOAA–9) although consideration was also to be given to the IR channels (Channel 4: $10.5 - 11.5\mu m$ for TIROS–N, NOAA–6 and NOAA–8; and Channel 4: $10.3 - 11.3\mu m$, Channel 5: $11.5 - 12.5\mu m$ for NOAA–7 and NOAA–9). Because the signal from the dumped material is thought to be very weak and because of the substantial noise in Channel 3, this channel was not considered.

The reason that the EPA wished to consider AVHRR data for their monitoring program is the frequent coverage of the 106 dumpsite area by satellites carrying this sensor. In general, each satellite sees the area twice a day and there are generally two satellites collecting data; i.e., the dumpsite is covered beteween two and four times a day. NOAA–6 and NOAA–8 are in dawn–dusk orbits. Such orbits overfly any point at about 7:00 a.m. and 7:00 p.m. local sun time. TIROS–N, NOAA–7 and NOAA–9 are in orbits which overfly any point on the globe at 2:00 a.m. and 2:00 p.m. local sun time. This means that only one of the NOAA–7 and one of the NOAA–9 orbits overfly the dumpsite in daylight hours. NOAA–6 and NOAA–8 generally have both passes during daylight but at times corresponding to very low sun angles. This means that very little sunlight penetrates the water column, so, unless the dumped material is near the surface (top few centimeters) there will be little sunlight reflected from it; hence, it will be difficult at best to detect.

DATA SELECTION

Given the considerations outline above, the following procedure was adopted to select AVHRR passes for analysis. The EPA provided the daily dump logs kept by the U.S. Coast Guard for 1985. These logs give the date, time, and location of the dump as well as other information such as type of material dumped, dumping vessel, etc. The dump logs were scanned for all dumping events at Dumpsite 106 and the 20 mile dumpsite. All AVHRR imagery within the URI archive obtained within ten days following each of the 106 or 20 mile dumps were then scanned for cloud cover at the two dump sites. The results of this are presented in Table 1.

Following the compilation of this table, all five channels for those passes corresponding to images sufficiently clear to warrant further analysis were ingested. A full resolution 512x512 sector was then extracted from the ingested pass centered on $73°W$, $40°N$ for each of the five spectral channels (NOAA–9; four channels for NOAA–6, the only other satellite providing useful data during the 1985 study period.) Only eight bits of the 10 were used so as to render more convenient display of the images on the URI system. The bias

was cchosen so that the eight bits selected were those containing the relevant information. Finally, all sectors of all images were remapped to a coordinate system rectangular in longitude and latitude and centered on $72°30'W$, $39°42'N$. The spacing of pixels was chosen as 0.010° in latitude and 0.013° in longitude.

In addition to the five images corresponding to the five spectral channels, two additional images were generated, the difference between channel 1 and channel 2 and the ratio of channel 1 to channel 2.

DATA ANALYSIS

Following the prepocessing described above, 18 of the 20 passes, indicated with a † in Table 1, were displayed on a color terminal and anomalies in either channel 1, channel 2, the difference between these channels or their ratio were sought in the appropriate dump area. Two of the 20 images indicated with a † in Table 1 were nighttime images selected because other daytime images existed for the particular dump being considered and it was thought that if the dump were observed such data could be used to study flow patterns in the area. In order to locate Deepwater Dumpsite 106, the square between $72°W$ and $72°30'W$ and between $38°40'N$ and $39°N$ was displayed on the monitor with the image. Below a description is provided on an image–by–image basis of the observations made. In these descriptions the 106 square often referred to is that defined above. The number following the satellite type, year, day and hour used to designate the pass being discussed corresponds to the dumpsite for which there was a dump preceeding the pass. A K Preceeding the time information corresponds to NOAA–9 and an N to NOAA–6.

N8506212 – 106 – Thick clouds to the southwest. Scattered clouds to the northeast. The 106 square is clear. Nothing apparent. Channel 4 shows what appears to be significant cross isobath circulation in the 106 square.

K8506818 – 106 – This image is very clear. Nothing observed in the 106 square. Two thin streaks, one from $73°13'W$, $39°52'N$ to $71°55'W$, $39°15'N$ and the other from $72°34'W$, $39°16'N$ to $72°11'W$, $39°04'N$ are apparent. They are very straight and do not appear in the IR channels. They are too long for a dump and most probably arise from scan line noise. Nothing else out of the ordinary was observed in any of the other images associated with this pass.

K8508618 – 106 – Light scattered clouds. Seems to be a pair of jet contrails crossing each other in the 106 square. These contrails are visible in all of the channels. There are many other contrails visible elsewhere in the images, hence the atmospheric conditions were right for their formation. The light scattered clouds render it too confusing to say positively whether or not there are other anomalies but

there was nothing obvious.

N8512012 – 106 – Very clear. Significant cyclonic circulation associated with a large meander to the east. Probably a lot of current and a lot of horizontal shear. Water in this area is of higher reflectance than shelf water, i.e. it is lighter in the channel-1 and -2 images. There is a plume evident in all channels ending at $73°25'W$, $38°57'N$. This plumes comes from the northeast and extends back to the shelf edge. It is clearly associated with shelf water being pulled off of the shelf by the shingle.

N8512923 – 20 – Clear but nothing is apparent in the visible channels.

N8514611 – 20 – Very clear. Channel 4 shows a small shingle in the 106 square. The Gulf Stream touches the bottom of the box. Can not see any anomalies in the visible channels.

K8515418 – 20 – Very hazy over the entire shelf region. This haze adds too much variablility to the visible data to see weak anomalies.

K8522518 – 106 – A few pixel sized clouds evident in the dumpsite area. Nothing else visible. In the thermal–IR channels a large shingle of the Gulf Stream with part of the Gulf Stream itself extending into the 106 square is evident. There are probably strong currents and a lot of horizontal shear associated with the stream and shingle. Any dumped material would most probably be quickly spread out and advected away from the dumpsite.

K8522618 – 106 – Although no clouds per se are evident in the 106 square, there are clouds to the southeast and the square itself seems to be very hazy. The Gulf Stream meander has moved to the east by about 15′. There is nothing else evident in any of the images associated with this pass.

K8525818 – 106 – Some clouds in the square make it difficult to determine if there is anything of interest. There is nothing obvious.

K8328019 – 106 – Clear on the shelf. Scattered small clouds (several pixels in size) in the 106 square. Cloudy to the north and to the east. Nothing apparent in the visible channels. There is a large warm core ring centered on the square. Again there is probably a lot of shear. The clouds are associated with the outer portion of the ring.

K8528119 – 106 – Similar to K8518019 except more clouds and the ring has moved west by

about 10 km. Again no apparent dump although light clouds make it difficult to see, i.e. we could well miss a weak signal in the visible channels.

K8528318 – 106 – over one half of the square is cloudy. Very difficult to see anything. Nothing apparent in the clear regions.

K8528418 – 106 – Scattered clouds uniform throughout the 106 square. Impossible to see anything.

K8530218 – 20 – Clear nothing out of the ordinary.

K8530518 – 20 – Not as clear as K8530218. Nothing out of the ordinary.

K8534519 – 106 – Cloudy over the 106 square.

K8536519 – 106 – Although the image looks clear, on closer inspection channel 1 shows haze over the entire area. The structure of the haze in the 106 square makes it very difficult to see any structure in the water.

DICUSSION

No dump plumes were observed in any of the images analyzed. Many of the images which appeared to be clear when the data were initally scanned often had light scattered clouds in them when processed at full resolution. Such clouds make it difficult to impossible to detect a weak signal in the visible channels. It is clear from this work that the dumps if apparent in the AVHRR visible data will be very weak. This means that to observe these dumps the area will have to be absolutely clear, no scattered clouds and no haze. Furthermore, there will have to be significant solar penetration in the water column. The very clear dawn–dusk images showed nothing.

One might ask why dumps are detectable in LANDSAT data and not in AVHRR data. The primary reason relates to the spatial resolution. LANDSAT MSS data has a resolution of 80 m compared to the 1.1 km resolution of the AVHRR. In the LANDSAT data, dumps at the 12–mile site although 10's of kilometers long are generally less that 1 km wide. To see such a dump in AVHRR data would require a substantial difference in reflectance with that of the surrounding waters.

It may be possible to see ocean dumps from AVHRR data but one would have to know exactly where to look. In this study we were only provided with the date of the dump and the dumpsite, not the precise location of the dump. But unless the dumps actually occurred far from the 106 square used in this analysis the signal even if detectable is far

too weak to be of value in a monitoring programs.

We suggest the analysis of LANDSAT Thematic Mapper data to determine the size and spectral signature of the dumps. With this knowledge it would be fairly straight forward to determine whether or not AVHRR visible data has any promise at all. We doubt it.

Our assumption is that CZCS data would provide a slightly better chance of seeing dump plumes because NIMBUS–7 passes overhead at approximately local noon when the penetration of solar radiation into the water coulmn is a maximum and because there are more spectral channels in the visible and these channels have higher radiometric resolution than the AVHRR channels. We did not look at CZCS data because the dumps designated by the EPA were all in 1985. The degradation of the CZCS sensor is such that by 1985 the data are of very low quality.

Table 1. Dump Information for 1985

DAY	SITE	DAY	SAT	TIME	DESCRIPTION
008	106				
		009	K	07	clouds over whole area
019	106				
		019	K	07	clouds over whole area
		024	M	20	clds over both areas
		029	K	18	clouds over whole area
035	106				
		036	K	07	clear over both areas, rest of image cloudy
		038	K	07	cloud over 12, scattered cloulds over 106
		049	M	20	clear over both areas
051	106				
		058	M	20	scat clds over both areas
060	106				
		062†	N	12	clear over both areas
		062	N	23	clear over both areas
067	106				
		068†	K	18	clear over both
		074	K	18	clear over 12, cloudy over 106
082	106				
083	106				
		083	K	19	both areas are cloudy
086	106				
		086†	K	18	clear over 12 fairly clear over 106
		088	K	18	clouds over both areas
094	106				
102	106				
107	106				
		112	N	12	scat clds over 12, clds over 106
119	106				
		120†	N	12	clear over both area
		125	N	23	no image
		126	N	22	clds over both areas
127	20				
		127	K	08	clouds over 12, clear over 106
		129†	N	23	clear over both areas
		136	N	12	clds over 12, scat clds over 106
		136	K	18	clear over 12, fairly clear over 106
		136	K	08	clouds over 12, clear over 106
		137	K	06	no image
		137	K	08	clouds over both
		140	K	19	clear over both areas
		140	N	22	clear over 12, scat clds over 106

Table 1. Dump Information for 1985 (continued)

DAY	SITE	DAY	SAT	TIME	DESCRIPTION
143	106				
		146†	N	11	clear over both areas
		151	N	11	clds over both areas
152	106				
154	20				
		154†	K	18	clear over 12, fairly clear over 106
		158	K	07	clear over both areas
		162	K	07	no image
164	106				
		165	N	12	clds over 12, scat clds over 106
168	20				
172	106				
		172	K	06	clear over both areas
179	106				
183	106				
186	20				
		189	L	12	clear over both areas
191	106				
		195	K	07	clear over 106, not clear over 12
		201	K	18	fairly clear over 12, and clear over 106
		202	K	18	clear over 12, scat clds over 106
203	106				
214	106				
		220	K	06	12 cloud covered, 106 scat clds
224	106				
		224	K	07	clear over both
		225†	K	18	clear over both
		225	K	07	clear over both
		226†	K	18	clear over both areas
		226	K	07	clouds over 12, scat clds over 106
		228	K	07	clear over both areas
235	106				
241	20				
		241	K	08	scat clds over both areas
245	106				
249	106				
		252	K	07	cloudy over 12, clear over 106

Table 1. Dump Information for 1985 (continued)

DAY	SITE	DAY	SAT	TIME	DESCRIPTION
258	106				
258	106				
		258†	K	18	high clds over 12, clear over 106
		259	K	08	clear over both areas
		261	K	07	no image
		262†	K	07	high clds over 12, clear over 106
263	20				
		272	K	19	clear over both areas
		273	K	07	clear over both areas
		274	K	07	clear over both areas
		274	K	18	clear over 12, high clds over 106
		275	K	07	foggy over 12, clear over 106
		275	K	18	cloudy over both areas
		276	K	18	cloudy over both areas
		279	K	19	cloudy over 12, clear over 106
280	106				
		280	K	07	clear over 12, high clds over 106
		280†	K	19	clear over both areas
		281	K	17	no image
		281†	K	07	clear over both areas
		281†	K	19	high clouds over 12, clear over 106
		282	K	07	clear over both areas
		283†	K	18	clds over 12, scat clds over 106
		283	K	07	high clds over 12, clear over 106
		284†	K	18	clear over 12, scat clds over 106
		285	K	06	clear over 12, high clds over 106
		285	K	18	high clds over both areas
		287	K	18	scat clds over 12, clear over 106
		288	K	17	clds over 12, clear over 106
		288	K	08	scat clds over 12, clear over 106
		290	K	19	scat clds over 12, clear over 106
		290	K	07	no image
		291	K	18	clds over 12, scat clds over 106
		291	K	07	clds over 12, clear over 106
		292	K	18	clds over 12, clear over 106
		292	K	07	scat clds over 12, clear over106
		296	K	08	clear over both images
		296	K	18	clear over both areas
		296	K	06	nothing for 12, clear over 106
		300	K	07	no image

Table 1. Dump Information for 1985 (continued)

DAY	SITE	DAY	SAT	TIME	DESCRIPTION
301	20				
		302†	K	18	high clds over 12, clear over 106
		305†	K	18	hazy over 12, clear over 106
		311	K	18	scat clds over both areas
		312	K	07	no image
		329	K	19	clear over 12, clds over 106
337	106				
		338	K	07	clds over both areas
		339	K	18	clds over both areas
		343	K	06	clds over both areas
		344	K	19	clds over both areas
		344	K	06	no image
345	106				
		345	K	06	no image
		345	K	08	clds over both areas
		345†	K	19	clds over 12, clear over 106
		346	K	07	clds over both areas
		347	K	07	no image
		347	K	19	clds over both areas
		348	K	18	clds over both areas
		349	K	07	clear over 12, clds over 106
350	106				
		350	K	07	clear over 12, scat clds over 106
		351	K	06	clear over 12, scat clds over 106
		352	K	06	clds over both areas
356	106				
		357	K	07	clds over both areas
358	106				
		358	K	07	clds over both areas
		359	K	18	clds over both areas
		361	K	18	clear over 12, scat clds over 106
		363	K	06	no image
		363	K	19	clear over both areas
364	106				
		364	K	19	clear over 12, clds over 10
		365	K	07	clear over both areas
		365†	K	19	clds over 12, clear over 106

† This image processed.